

U. S. Observ

# REPORT

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OF THE



## SUPERINTENDENT

OF THE

# UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1897.



WASHINGTON:  
GOVERNMENT PRINTING OFFICE.  
1897.



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UNITED STATES NAVAL OBSERVATORY,  
Washington, D. C., July 15, 1897.

SIR: I have the honor to submit herewith the report of the operations of the United States Naval Observatory for the fiscal year ending June 30, 1897.

DEPARTMENT OF ASTRONOMICAL OBSERVATIONS.

The Astronomical Director reports as follows:

THE 26-INCH EQUATORIAL TELESCOPE.

[Prof. STIMSON J. BROWN, U. S. N., in charge.]

As usual, this instrument has been employed almost exclusively on faint and difficult objects which could not well be reached by smaller telescopes. The work accomplished during the year ending June 30, 1897, was as follows:

Brook's periodic comet, 1889 V = 1896 VI, was observed twenty-three times.

Giacobini's comet, 1896 V, was observed five times.

Perrine's comet, 1896 f = 1897 I, was observed on November 6, 8, and 9. On the latter date it was visible in the 5-inch finder, and therefore the work of making further observations on it was transferred to the 12-inch equatorial.

Perrine's periodic comet, 1896 VII, was observed three times.

The observations of these four comets have all been completely reduced and published in the volumes of the Astronomical Journal.

During the months of May and June an attempt was made to find D'Arrest's comet, the ephemeris used having been carried forward from the last apparition, but the search proved unsuccessful, partly on account of unfavorable weather and partly because the motion of the comet kept it continually on the verge of the morning twilight.

The satellites of Mars were observed whenever possible from November 18 to December 28, 1896, and during that period 24 observations of Deimos and 6 observations of Phobos were made by the method of position angles and distances.

On March 29, 1897, observations were begun on what is intended to be a general revision of the more important double stars, such as well-known binaries, suspected binaries, and new or difficult doubles. Although nearly every subsequent clear night, except Sundays, has been utilized for that purpose, only 98 observations have been secured, while an equal number of attempts proved futile. Out of thirty-nine nights of actual work fifteen proved fairly good, but on only three of them could so high a power as 888 be used. On the remaining twenty-four nights observations were either impossible or limited to objects which would have been easily within reach of a 12-inch telescope under favorable conditions of weather. As a part of this work, Sirius and Procyon were examined in the early twilight, but the condition of the sky was unfavorable, and nothing was seen of their companions.

Last January the Moon passed very near to Mars, and arrangements were made to secure photographs of the spectra of the two bodies under nearly identical conditions. Trial spectra were obtained on both objects, but a long period of cloudy weather rendered the bodies invisible at the time of the January conjunction, and when the February conjunction arrived Mars was so far from the Earth that the scheme was impracticable.

The diameters of Mercury and Venus have been measured with the filar micrometer whenever sufficiently favorable conditions occurred. The observations of Mercury have little value on account of the unsteadiness of the images, but on three occasions the images of Venus were very fine for daylight observations, and as the resulting diameter of the planet at distance unity they gave, respectively, 17.60'', 17.65'', and 17.56''.

In addition to the usual routine office work the observations of Titan and Iapetus for 1894, 1895, and 1896 have been completely reduced, and the solution of the normal equations for the correction of the elements has been finished, but as the work has all been done by Professor Brown he thinks it should yet be checked by some one else, in order to guard against the possibility of systematic errors in the computed coordinates and in the coefficients of the observation equations. There were 150 equations of condition, equally distributed between the three years, and also between the two coordinates  $\Delta\alpha$  and  $\Delta\delta$ . The probable error of a single observation is  $\pm 0.313''$ , and the resulting mass of Saturn is, from Titan 1:3490.3, and from Iapetus 1:3489.2.

The 26-inch telescope has remained in admirable order throughout the year, and no changes whatever have been made in it. On August 28, 1896, the contact piece for automatically stopping the elevating floor when it reaches its highest point was accidentally broken, and on September 9 it was replaced by a new casting. As originally arranged, the water pressure for raising and lowering the elevating floor was obtained from a pair of steam pumps situated in the basement of the main building of the Observatory. This was inconvenient, because 60 pounds of steam was required to work the pumps, and that pressure seldom existed in the boilers unless it was specially gotten up for the purpose. When the water from the new high-service reservoir was laid on to the city mains it was found that the pressure in them was about 74 pounds per square inch, and although that was 16 pounds less than the pressure usually given by the steam pumps, the Superintendent of the Observatory suggested that it might suffice to work both the elevating floor of the 26-inch telescope and the elevator in the main building. This suggestion having been confirmed by a rough calculation,

on December 7, 1896, the city water pipes were connected with the elevating apparatus in question, and although the floors rose rather more slowly than under the action of the steam pumps, they have been worked in that way ever since because the diminution of speed is more than compensated for by the circumstance that the water pressure is always available.

Ever since the removal from the old Naval Observatory, the chronograph belonging to the meridian instrument Stackpole & Brother, No. 1502, has been used in connection with the 26-inch equatorial, because the chronograph properly belonging to the latter instrument required a space of 106 inches for the fall of its weight, and that could not conveniently be obtained in the new buildings. During the present summer the last-mentioned chronograph was put into the hands of Messrs. Warren & Swasey, with instructions to reduce the fall of its weight to 36 inches. That having been done, the instrument was returned to the Observatory on June 14, 1897, and will be brought into use as soon as possible.

#### THE 12-INCH EQUATORIAL TELESCOPE.

[Prof. EDGAR FRISBY, U. S. N., in charge.]

The work done with this telescope during the year ending June 30, 1897, was as follows:

Thirty-three observations of asteroids were made, namely, 3 of Flora (8), 2 of Psyche (16), 3 of Nemausa (51), 1 of Sappho (80), 2 of Sylvia (87), 2 of Amalthea (113), 3 of Electra (130), 3 of Ismene (190), 6 of Nephthys (287), 1 of (346), 5 of (386), and 2 of (387).

Perrine's comet, 1896 f=1897 I, was observed six times.

Perrine's periodic comet, 1896 g=1896 VII, was observed six times.

The positions of two stars were measured for use in connection with the work of the 26-inch telescope.

Eight occultations of stars by the moon and 5 eclipses of Jupiter's satellites were observed.

The diameter of Venus was measured on seven different days, and the Sun was examined for spots on four days.

Nearly all of the above-mentioned observations are reduced up to date, and those requiring prompt publication have been printed in the Astronomical Journal. In addition to this, Professor Frisby has found time to compute an ephemeris of the rising and setting of the moon at Washington for the year 1897, and also to do a great deal of work on the reduction of the photographs of the transit of Mercury of November 10, 1894.

On Tuesday and Thursday evenings of each week, weather permitting, the 12-inch telescope has been used for the exhibition of celestial objects to visitors. During the year 3,260 permits were issued to such visitors by the Observatory, and a large additional number were issued by the Bureau of Equipment.

During the last twelve months certain additions and repairs were made to this telescope by Mr. M. E. Kahler, as follows:

September 3, 1896, a new leather cap was provided for the finder. September 8 a clamp was provided for the draw tube of the finder, and, as the diaphragms in the sliding tube of the main telescope cut off the outer edge of the field when low-powered Huygenian eyepieces were employed, they were removed and replaced by larger ones. The object glasses furnished with the long microscopes for reading the right

ascension and declination fine circles gave very bad definition on account of excessive spherical aberration, and to remedy that defect they were replaced by new objectives ground to curves specially computed by the Astronomical Director, the change being made in the declination microscopes on December 1, and in the right ascension microscopes on December 26. About the middle of February, 1897, the machinery of the dials for indicating the position of the telescope got slightly out of order, and on February 18 it was taken down, cleaned, oiled, and repaired.

#### THE 9.14-INCH TRANSIT CIRCLE.

[Assistant Astronomer AARON N. SKINNER, in charge.]

In the work with this instrument Assistant Astronomer Skinner has been aided during the year, for the periods specified, by the following-named gentlemen:

Assistant Astronomer H. M. Paul to February 15, 1897, when he was transferred to the time service; Mr. Theo I. King throughout the year, in the grade of computer until April 20, 1897, and subsequently in the grade of assistant astronomer; Computer Frank B. Littell until September 21, 1896, when he resigned, and after June 19, 1897, when he was reinstated; Computer E. A. Boeger throughout the year; Computer G. K. Lawton from the date of his appointment, October 20, 1896. Since March 23, 1897, Computer William M. Brown has aided in the observing, but not in the computing.

As the observations for the German Astronomical Society's zone, lying between  $13^{\circ} 50'$  and  $18^{\circ} 10'$  of south declination, were substantially completed last year, while the reductions are still far in arrears, it was thought best to limit the work of the transit circle during the present year to observations of the Sun, Moon, and planets, together with such stars as were wanted for special purposes, and the minimum number of Ephemeris stars necessary for determining instrumental constants.

The observations actually made during the twelve months ending June 30, 1897, were as follows:

Stars required for completing the zone— $13^{\circ} 50'$  to  $-18^{\circ} 10'$ , 435; zero stars for zones, 148; American Ephemeris stars, 2,832; miscellaneous stars, 109; wire interval stars, 73; Sun, 177; Moon, 122; Mercury, 87; Venus, 140; Mars, 44; Jupiter, 45; Saturn, 59; Uranus, 58; Neptune, 39; Flora (8), 6; Psyche (16), 6; Nemausa (51), 13; Sappho (80), 4; (346), 7. Total, 4,404.

In compliance with special requests, the positions of certain stars were observed and furnished to the parties named, as follows:

From the zone— $13^{\circ} 50'$  to  $-18^{\circ} 10'$ , 88 star places to Dr. J. G. Hagen, S. J., of Georgetown College Observatory, Washington, D. C., and 12 star places to Mr. A. Stichtenoth, of Göttingen, Germany; each of these places depending on two or more observations. To Prof. J. R. Eastman, U. S. N., 4 star places were furnished; to Prof. Edgar Frisby, U. S. N., 2 star places were furnished, each depending upon three observations; and to Prof. S. J. Brown, U. S. N., 9 star places were furnished, each depending upon three to five observations. For Prof. C. L. Doolittle, of the Flower Observatory, Philadelphia, Pa., observations have been made upon 6 stars, but they are not yet reduced.

The state of the reductions of the zone observations is as follows: In right ascension, the interpolation of the clock corrections has been fin-

ished, but no progress has been made in the interpolation in the reductions from the date of observation to 1900. In declination, the interpolation of the refractions has been finished, but no progress has been made in the interpolation of the reductions from the date of observation to 1900. The work necessary for completing the reductions is as follows: The preparation of the reduction tables for zones 165-182, inclusive; the interpolation of the reductions in right ascension and declination from the date of observation to 1900; the assembling of the observations in the order of right ascensions and the taking of the means; the computation of the annual precessions and secular variations, both in right ascension and in declination.

The state of the reductions of the observations of the Sun, Moon, and planets is as follows: The chronograph sheets have been read to date; the means of the times of transit, microscope readings, and telescope micrometer readings have been taken to May 13, 1897; the observations have been partially entered on the reduction sheets, and a small amount of work has been done on these sheets. The work necessary for the completion of the reductions is as follows: The completion of the means of the times of transit, microscope readings, and telescope micrometer readings; the completion of the entries on the reduction sheets; the reduction on the sheets of all the Sun, Moon, and planet work from October 10, 1894, to date, only a small part of which has been done.

A comparison of this statement with the report of July 1, 1896, shows that the reductions have fallen further into arrears during the last fiscal year. This is due to two facts: First, the computing force attached to the transit circle at the beginning of the year was too small to do the work required of it, and, second, that force was diminished by one man from February 15, 1897, when Assistant Astronomer Paul was transferred to the time service, until June 19, 1897, when Computer Littell was reinstated.

Experience having shown that the meridian mark belonging to the transit circle was considerably inside the principal focus of the lens used for viewing it, an alteration in the position of the mark became necessary. The place which it should occupy having been very carefully determined, a hole was dug in the ground 6 feet square and 6 feet deep. This was filled with concrete, and upon the latter was built a brick pier  $35\frac{1}{2}$  inches square and  $35\frac{1}{2}$  inches high. The pier was capped with a marble slab 38 inches square and  $4\frac{1}{2}$  inches thick, upon which the meridian mark was mounted. The exact distance from the long focus lens to the new meridian mark was found to be 380.0 feet, which is 7.87 feet greater than the distance of the old mark. The new pier was built during the month of October, 1896, and the mark was transferred to it on October 28.

The illumination of the field of the transit circle being unsatisfactory when bright webs were required on a dark ground, a study of the illuminating apparatus was made, and it was concluded that the difficulty might be remedied by substituting for a certain plano-convex lens situated inside the axis of the telescope a lens which should be spherical on one side and cylindrical on the other. The best curves could be determined only by trial, and the first experimental lens made by Mr. M. E. Kahler did not prove sufficiently powerful. A second lens, furnished on January 19, 1897, has both its spherical and its cylindrical surface ground to a radius of 0.60 of an inch, and as it gave very good results it has been used ever since.

During the month of June, 1897, a new clock pier of white Rutland marble, weighing 3.6 tons, and measuring 28 by 32 inches at the base, 24 inches square at the top, and 102 inches high was erected on the east side of the east transit circle room to take the place of the temporary pier which had stood on the west side of that room since June, 1892. At the same time three additional clock piers of Richmond granite, each weighing 2.3 tons, and measuring 25 by 30 inches at the base, 24 inches square at the top, and 75 inches high, were erected in the clock room, but the clocks have not yet been mounted upon any of these four piers.

On September 3, 1896, the outer disk on the head of the zenith distance micrometer of the transit circle was accidentally bent, and was repaired the next day by Mr. Kahler. On May 6, 1897, the same gentleman furnished two collimating eyepieces, one for the main telescope of the transit circle, and the other for the vertical collimator; and on May 20 he furnished dew caps for the objectives of the two horizontal collimators.

#### THE PRIME VERTICAL TRANSIT INSTRUMENT.

[Assistant Astronomer GEORGE A. HILL, in charge.]

This instrument has been used in connection with the meridian instrument Stackpole & Brother No. 1502 for determining variations of latitude and the constants of aberration and nutation, precisely as described in former reports, except that the stars 40 Aurigæ and 1450 Groombridge have been added in order to increase the possible number of observations at certain seasons of the year.

The number of observations obtained during the twelve months ending June 30, 1897, was as follows: With the prime vertical transit instrument,  $\mu$  Andromedæ, 17;  $\alpha$  Canum Venaticorum, 35;  $\theta$  Aurigæ, 37;  $\gamma$  Bootis, 30; 40 Aurigæ, 4; Groombridge, 1450, 6;  $\alpha$  Lyrae, 111. With the zenith telescope,  $\alpha$  Lyrae, 120. Total 360 observations.

All observations made with the prime vertical transit instrument are copied on the reduction sheets up to June 30, 1897, reduced up to March 10, 1897, and transcribed for the printer up to October 15, 1896. The observations made with the zenith telescope are reduced up to October 20, 1896.

The entire series of observations made with the two instruments between July 24, 1893, and October 15, 1896, has been reduced, and the discussion of the observations for the latitude and variation of latitude at this observatory has been published in No. 404 of the Astronomical Journal. The value found for the latitude of the center of the clock room is  $+38^{\circ} 55' 13.70'' \pm 0.10''$ .

Both instruments have remained in excellent condition throughout the year. In the meridian instrument Stackpole & Brother No. 1502 no change whatever has been made, and in the prime vertical transit instrument only the mirrors employed in reading the striding level have been made a little wider. The latter change was effected on September 18, 1896, and about the same time there was purchased from Mr. Kahler, for the purpose of testing the pivots of the prime vertical transit, one spherometer caliper, of the kind described in the Monthly Notices of the Royal Astronomical Society (London), 1878, volume 38, pages 487-493.

#### THE TRANSIT CIRCLE STAR CATALOGUE.

[Prof. JOHN R. EASTMAN, United States Navy, in charge.]

In the preparation of this catalogue Professor Eastman has been assisted throughout the year by Mr. F. H. Parsons, temporarily

employed for the purpose, and by Computer William M. Brown, who has devoted rather more than two-thirds of his time to the work. During the last twelve months the secular variations of the precessions have been computed and checked, and in order to guard against errors, these quantities, together with the positions of nearly all the stars, have been compared with the results obtained by other authorities. Several weeks were lost in correcting small systematic errors which were introduced into the star places in consequence of an unfortunate verbal statement got from the office of the American Ephemeris in 1896. The annual positions and catalogue places of the standard stars were completed several months ago, and the annual positions and catalogue places of the miscellaneous stars, together with the general introduction to the catalogues, are now nearly ready for the printer.

#### MISCELLANEOUS MATTERS.

During the year a large amount of work has been done toward the reduction of the photographic observations of the transit of Mercury of November 10, 1894. The greater part of this work is due to Professor Frisby, but Computer William M. Brown and Photographer Charles T. Fellows have also rendered effective services.

While the shutters on the various observing rooms work very satisfactorily under all ordinary circumstances, they have never been quite tight against rain storms with the wind at right angles to the openings in the roofs, and at such times a good deal of water penetrates to the instruments. Furthermore, many of the screws, which hold the zinc lining to the interior sides of the east transit circle room, have worked out, and consequently the sheets have become so much loosened that they present a very dilapidated appearance. These defects require attention.

During the year the following-named articles have been added to the permanent equipment of the Astronomical Department: July 6, 1896, a pair of 16-inch globes mounted on high stands. August 1, a Blickensderfer typewriter, for use in preparing the transit circle star catalogue. October 7, one 6-figure arithmometer.

Very respectfully,

WM. HARKNESS,

*Professor of Mathematics, U. S. N., Astronomical Director.*

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#### DEPARTMENT OF THE NAUTICAL ALMANAC.

Prof. Simon Newcomb was the Director of the Nautical Almanac from the beginning of the fiscal year until March 12, 1897, upon which date he was placed on the retired list, under the provisions of section 1444, Revised Statutes. Prof. William W. Hendrickson, by order of the Department, succeeded him. On June 30, 1897, Professor Hendrickson was detached and Prof. William Harkness was directed to assume the duties of Director of the Nautical Almanac in addition to his duties as Astronomical Director.

Professor Hendrickson submits the following report:

#### PRINTING.

The American Ephemeris for 1899 and the American Nautical Almanac for 1900 have been published. Owing to the introduction of new

tables, constants, and other data in the Ephemeris for 1900, the printing of that volume has been delayed; 400 pages are now in print, and copy for the remainder is substantially ready for the printer.

Part I, Volume VIII of the Astronomical Papers, "A new determination of the precessional constant," is in press.

#### DISTRIBUTION.

During the fiscal year ending June 30, 1897, the sale and distribution of publications have been as follows:

Title.	Sold.	Distributed.	Public service.	Total.
American Ephemeris .....	509	494	568	1,571
American Nautical Almanac .....	1,958	6	302	2,266
Pacific Coaster's Almanac .....	1,254	3	35	1,292
Astronomical Papers .....	44	470	1	515

The proceeds of sales, amounting to \$1,278.35, have, in compliance with law, been deposited in the Treasury to the account of the appropriation for printing and binding.

#### NEW TABLES OF THE PLANETS.

Upon the retirement of Prof. Simon Newcomb, in March, 1897, he was appointed to supervise the completion of the tables of the planets, so that this work has been under his direction during the year. Two skilled computers have been employed upon the tables of Uranus and Neptune and the revision of the theory of Mars. Additional computers have also been assigned to this work whenever they could be spared from other office duties.

#### EPHEMERIS OF THE FIXED STARS.

During the year a part of the office force has been constantly employed in the preparation of an International Catalogue of Standard Stars. The computations have been made in cooperation with the office of the British Nautical Almanac and the French Bureau des Longitudes.

Definitive mean places and annual variations for 1900 have been completed for all the stars given in the American Ephemeris, and these results have been used in the preparation of the volume for 1900. The completion of the catalogue, with the necessary checks and its preparation for the press, will probably occupy the greater portion of another year.

The adoption of new constants in the Ephemeris for 1900 made it necessary to prepare new tables for the reduction of mean to apparent places. These tables, 383 in number, have been completed and have been used in the preparation of the Ephemeris.

Very respectfully,

W. W. HENDRICKSON,  
*Professor of Mathematics, U. S. N., Director Nautical Almanac.*

## DEPARTMENT OF NAUTICAL INSTRUMENTS.

Lieut. F. W. Kellogg, U. S. N., the head of this department, was detached July 8, 1896. The next officer in charge was Lieut. C. H. Lyman, U. S. N., from November 20, 1896, until his death, on January 28, 1897. Lieut. T. M. Brumby, U. S. N., was in charge from March 10 until June 1, 1897, when he was ordered on temporary duty at the Naval War College, Newport, R. I.

During the absence of Lieutenant Brumby, Lieutenant-Commander Goodwin has had charge of this department, in addition to his other duties. He reports as follows:

The classes of nautical instruments issued from the Observatory include sextants, octants, spyglasses, binocular glasses, protractors, stadiometers, reading glasses, drawing instruments, theodolites, measuring tapes, plane tables, psychrometers, thermometers, barometers, deck and boat clocks, clinometers, photographic outfits, parallel rulers, magnetic instruments, and other instruments issued to ships for navigating and surveying purposes.

Sextants and octants are inspected for accuracy of dimensions, form and fit of pivot, graduation of arc and vernier, optical performance of telescopes, shade glasses, eccentricity of limb, parallelism of faces of mirrors, weight, quality of workmanship, and conformity in other respects with the specifications.

Spyglasses and binoculars are inspected for power, field, clear aperture, focal distance, and mechanical construction, as set forth in the specifications for the several grades of glasses. Other instruments are inspected for conformity to detailed specifications that are attached to the requisitions calling for them.

The following instruments were rejected as failing to comply with the detailed specifications or required tests:

Stop watches (silver) .....	23
Three-arm protractor .....	1
Maximum and minimum thermometer .....	1
Aneroid barometers .....	5
Surveying sextants .....	5
High-grade sextant .....	1
Mercurial barometers .....	2
Spyglasses, low power .....	5
Chronometers .....	8

The cost of the various instruments purchased during the past fiscal year for issue is \$15,546.31. The invoice value of the instruments issued to ships of the Navy during the year is \$26,731.26.

The following instruments were received, inspected, and accepted during the year:

Chronometers .....	4
Binoculars:	
Day .....	54
Night .....	150
Spyglasses, low power .....	46
Sextants, high grade .....	16
Sextants, surveying .....	2
Octants .....	11
Sets, splines, and weights .....	20
Three-arm protractors .....	11
Psychrometers .....	20
Mercurial barometers .....	20
Clinometers .....	32

Spyglasses, officer of the deck .....	125
T-squares .....	20
Deck clocks .....	50
Steel tapes .....	25
Thermometers, air and water .....	200
Stadiometers (Fiske) .....	5
Cases drawing instruments .....	20
Maximum and minimum thermometers .....	30
Captain's reading glasses .....	20
Navigator's dividers .....	20
Parallel rulers .....	95
Aneroid barometers .....	15

During the year 3,260 permits have been issued to visitors to visit the Observatory for a view of the heavens through the telescope, and a large additional number were issued by the Bureau of Equipment.

Very respectfully,

WALTON GOODWIN,  
*Lieutenant-Commander, U. S. N., General Storekeeper.*

#### DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

Lieut. W. V. Bronaugh, U. S. N., was the head of this department until his detachment from the Observatory on February 20, 1897, and Assistant Astronomer H. M. Paul was in charge until March 31, 1897, when he was succeeded by Lieut. Chas. E. Fox, U. S. N., who has been assisted by Professor Paul since that date.

Lieutenant Fox makes the following report:

The present disposition of all chronometers belonging to the Navy is shown by the following table:

Kind.	In service afloat.	In service on shore.	In store at Mare Island.	At Observatory for issue.	Undergoing repairs.	Awaiting repairs.	Total.
Standards .....	144	10	35	35	7	-----	231
Hacks .....	49	21	10	5	1	-----	86
M. T. B. C. .....	5	1	-----	-----	-----	-----	7
Sidereal B. C. .....	3	3	3	3	1	-----	10
Sidereal .....	1	1	-----	-----	1	-----	3
Thermometric .....	-----	-----	2	2	2	-----	4
Pocket .....	-----	-----	5	-----	-----	1	6

In addition to the above, there are in store 17 comparing watches for issue, 1 for repairs, and 2 for survey; 17 silver-case stop watches and 1 gold-case stop watch for issue; 27 maximum and minimum thermometers for issue, and 4 in use at the Observatory.

During the year 39 standard chronometers, 9 hacks, 9 stop watches, 11 comparing watches, and 11 thermometers have been issued to naval vessels.

The Observatory has received 15 standard chronometers, 2 hacks, and 2 comparing watches from naval vessels, and 1 standard chronometer, 1 hack, and 2 comparing watches from shore stations.

Two standard chronometers have been condemned as such and transferred to the hack list, and 1 hack, 1 comparing watch, and 2 thermometers have been condemned by survey and expended.

The annual trial of repaired chronometers commenced January 1, 1897, and was finished June 15, 1897. Twenty-six standard and 2 sidereal break-circuit chronometers were subjected to trial.

During the same period 10 chronometers submitted for purchase were also subjected to trial.

The following tables give the results of these trials in detail:

Relative number.	Time.....	Re-paired by—	Chronometer number.	Maker.	Jan. 1	Jan. 9	Jan. 18	Jan. 27	Feb. 4	Feb. 12
					to Jan. 8.	to Jan. 16.	to Jan. 25.	to Feb. 3.	to Feb. 11.	to Feb. 19.
					47.24	54.95	70.3	84.97	90.0	84.85
Temperature, Fahrenheit.....					68.7	69.7	71.8	69.9	69.9	69.8
Relative humidity, per cent.....										
1 Negus .....	1776	T. S. & J. D. Negus .....	+0.910	+0.561	-0.249	-0.670	-0.386	-0.701		
2 Bond .....	505	Wm. Bond & Son .....	-0.376	-1.189	-1.570	-0.884	-0.350	-1.059		
3 Negus .....	1764	T. S. & J. D. Negus .....	+0.124	-0.653	-0.999	+0.044	+0.364	-0.237		
4 ..do.....	1748	do.....	-0.019	+0.276	+0.287	+0.151	+0.400	+0.656		
5 Bliss .....	2817	John Bliss & Co.....	+0.410	+0.204	-1.070	-0.456	-0.207	-0.523		
6 ..do.....	2851	do.....	-0.376	-1.010	-1.427	-1.277	-1.171	-1.273		
7 Negus .....	1444	T. S. & J. D. Negus .....	+1.339	+0.610	-0.177	+0.473	+0.900	-0.023		
8 ..do.....	1519 S. B. C.	do.....	-0.106	-1.085	-1.067	-0.046	+0.630	-0.041		
9 Bond .....	221	Wm. Bond & Son .....	-1.197	-1.367	-1.784	-1.849	-1.743	-1.951		
10 Negus .....	1787	T. S. & J. D. Negus .....	-1.911	-1.939	2.177	-1.634	-1.031	-1.451		
11 Bliss .....	464	Usher & Cole .....	+0.339	-0.046	-0.356	+0.473	+0.971	+0.727		
12 ..do.....	2792	John Bliss & Co.....	-0.233	-0.189	+0.287	+0.973	+1.543	+1.406		
13 Heinrich .....	1007	H. H. Heinrich .....	+1.553	+0.419	+0.144	+1.223	+1.900	+1.334		
14 Negus .....	1259	T. S. & J. D. Negus .....	+0.481	-0.328	-0.749	+0.651	+1.507	+0.656		
15 ..do.....	1762	do.....	+1.410	+0.561	+0.109	+1.187	+1.900	+1.334		
16 ..do.....	1636	do.....	+1.267	+0.490	+0.251	+1.223	+1.900	+1.406		
17 ..do.....	1536 S. B. C.	do.....	+1.539	+0.918	+0.600	+2.419	+3.344	+2.707		
18 ..do.....	1267	do.....	+1.731	+0.169	-0.784	-0.849	+0.150	-0.344		
19 ..do.....	1452	do.....	+1.339	+0.276	-0.784	-0.491	+0.079	-0.237		
20 ..do.....	1772	do.....	-0.876	-1.046	-0.999	-0.563	-1.171	-2.023		
21 ..do.....	509	Wm. Bond & Son .....	+4.196	+3.490	+3.573	+4.366	+5.150	+4.691		
22 ..do.....	1448	T. S. & J. D. Negus .....	-0.126	-0.974	-1.213	+0.223	+1.257	+0.799		
23 Bliss .....	2381	John Poole .....	+1.410	+0.276	-0.927	-0.349	-0.064	-0.523		
24 Bond .....	504	Wm. Bond & Son .....	-2.804	-1.581	-0.106	+0.187	-0.064	-0.273		
25 Negus .....	1189	T. S. & J. D. Negus .....	+1.553	+0.526	+1.823	+3.080	+2.007	+2.870		
26 ..do.....	1268	do.....	+0.660	-0.653	-1.999	-0.813	+0.543	+0.191		
27 Bond .....	272	Wm. Bond & Son .....	+0.839	+0.776	+0.823	+0.973	+1.793	+2.191		
28 Bliss .....	25568	M. F. Dent .....	+0.803	-0.653	-0.677	+0.473	-0.207	+0.477		
1 .....	1890	T. S. & J. D. Negus .....	-0.090	-1.081	-1.641	-0.777	-0.207	-0.880		
2 .....	1754	do.....	+3.017	+2.298	+1.930	+2.901	+3.579	+2.906		
3 .....	1872	do.....	+2.374	+1.454	+0.751	+1.651	+2.114	+1.191		
4 .....	1810	do.....	+3.910	+2.347	+1.037	+2.294	+2.757	+2.156		
5 .....	1021	H. H. Heinrich .....	-4.019	-4.453	-5.284	-4.491	-3.493	-4.201		
6 .....	994	do.....	-1.590	-1.831	-2.100	-1.920	-2.029	-3.201		
7 .....	1849	T. S. & J. D. Negus .....	+1.767	+0.490	-0.499	-0.456	-0.493	-1.166		
8 .....	1833	do.....	-0.019	-0.974	-2.034	-0.491	+0.543	-0.023		
9 .....	1874	do.....	+1.660	+1.133	+0.287	+0.901	+1.150	+0.370		
10 .....	1873	do.....	+2.017	+0.990	+0.251	+1.044	+1.293	+0.191		

## Record of trial of repaired chronometers—Continued.

Relative number.	Time .....		Maker.	Feb. 21	Mar. 3	Mar. 13	Mar. 23	Mar. 30	Apr. 6	
	Repaired by—	Chronometer number.		to Feb. 28.	to Mar. 10.	to Mar. 20.	to Mar. 30.	to Apr. 6.	to Apr. 13.	
				69.81	54.57	45.1	66.55	66.15	68.72	
Temperature, Fahrenheit .....	Relative humidity, per cent .....			68.6	65.2	72.4	53.4	49.0	51.7	
1 Negus ..	1776	T. S. & J. D. Negus ..		-0.413	+0.133	+0.691	-0.049	-0.026	-0.247	
2 Bond ..	505	Wm. Bond & Son ..		-1.699	-1.117	+0.227	-1.691	-1.561	-1.926	
3 Negus ..	1764	T. S. & J. D. Negus ..		-0.770	-0.331	+0.691	-1.227	-1.383	-1.426	
4 do ..	1748	do ..		+0.587	+0.919	+0.727	+0.951	+1.117	+1.110	
5 Bliss ..	2817	John Bliss & Co. ..		-0.377	-0.189	+0.299	+0.059	+0.331	+0.217	
6 do ..	2851	do ..		-0.913	-0.331	+0.334	-0.441	-0.811	-1.069	
7 Negus ..	1444	T. S. & J. D. Negus ..		-0.377	+0.419	+2.120	-0.370	-0.526	-0.819	
8 do ..	1519 S. B. C.	do ..		-0.860	-0.390	+0.386	-0.894	-0.806	-0.804	
9 Bond ..	221	Wm. Bond & Son ..		-1.877	-1.724	-1.666	-1.299	-0.919	-1.069	
10 Negus ..	1787	T. S. & J. D. Negus ..		-2.449	-1.974	-1.916	-2.584	-2.597	-2.747	
11 Bliss ..	464	Usher & Cole ..		+0.016	+0.204	-0.308	-0.084	-0.097	-0.176	
12 do ..	2792	John Bliss & Co. ..		+0.766	+0.454	+0.156	+0.380	+0.296	+0.217	
13 Heinrich ..	1007	H. H. Heinrich ..		+0.623	+1.240	+2.191	+0.594	+0.546	+0.539	
14 Negus ..	1259	T. S. & J. D. Negus ..		-0.341	-0.010	+0.834	-0.584	-0.776	-0.819	
15 do ..	1762	do ..		+0.873	+1.597	+2.549	+0.844	+0.510	+0.146	
16 do ..	1636	do ..		+0.980	+1.776	+2.049	+1.309	+1.296	+1.253	
17 do ..	1536 S. B. C.	do ..		+1.533	+1.540	+2.384	+1.071	+1.086	+1.017	
18 do ..	1267	do ..		-0.056	+1.133	+2.906	-0.441	-0.776	-1.140	
19 do ..	1452	do ..		+0.051	+1.419	+2.691	-0.156	-0.347	-0.676	
20 do ..	1772	do ..		-1.949	-0.724	-0.666	-1.763	-1.490	-1.569	
21 do ..	509	Wm. Bond & Son ..		+4.373	+4.740	+6.263	+2.987	+2.867	+2.789	
22 do ..	1448	T. S. & J. D. Negus ..		+0.087	+0.133	+0.763	-0.120	-0.169	-0.069	
23 Bliss ..	2381	John Poole ..		-0.520	+1.454	+2.191	-0.084	-0.383	-0.604	
24 Bond ..	504	Wm. Bond & Son ..		-0.591	-2.903	-3.666	-1.941	-2.204	-2.033	
25 Negus ..	1189	T. S. & J. D. Negus ..		+1.873	+2.454	+3.299	+1.630	+1.903	+1.789	
26 do ..	1268	do ..		-0.449	+0.633	+1.906	-0.691	-0.169	-0.354	
27 Bond ..	272	Wm. Bond & Son ..		+1.480	+2.347	+2.906	+1.523	+1.260	+1.181	
28 Bliss ..	25568	M. F. Dent ..		+1.123	+1.811	+2.441	+0.558	+0.700	+0.360	
1 .....	1890	T. S. & J. D. Negus ..		-1.591	-1.046	-0.023	-1.620	-1.811	-1.854	
2 .....	1754	do ..		+2.230	+2.847	+3.513	+2.559	+2.474	+2.431	
3 .....	1872	do ..		+0.551	+1.669	+2.441	+0.380	+0.403	+0.289	
4 .....	1810	do ..		+1.909	+2.454	+3.727	+1.166	+1.224	+0.967	
5 .....	1021	H. H. Heinrich ..		-5.341	-5.367	-4.880	-5.370	-5.311	-5.283	
6 .....	994	do ..		-3.091	-2.439	-1.630	-3.727	-3.097	-3.069	
7 .....	1849	T. S. & J. D. Negus ..		-1.449	+0.026	+1.191	-0.763	-0.561	-0.783	
8 .....	1833	do ..		-1.127	-0.260	+0.584	-1.370	-1.383	-1.461	
9 .....	1874	do ..		-0.591	-0.331	+0.084	-1.084	-1.240	-1.283	
10 .....	1873	do ..		-1.199	-1.153	-0.451	-1.334	-1.311	-1.390	
Relative number.	Time .....		Maker.	Apr. 13	Apr. 20	Apr. 27	May 4	May 11	May 18	
	Temperature, Fahrenheit .....	Relative humidity, per cent .....		to Apr. 20.	to Apr. 27.	May 4.	to May 11.	May 18.	to May 25.	
				70.17	68.66	69.46	72.67	71.01	68.39	
1 Negus ..	1776	T. S. & J. D. Negus ..		-0.253	-0.297	-0.303	-0.414	-0.404	-0.344	
2 Bond ..	505	Wm. Bond & Son ..		-2.003	-1.797	-2.017	-1.986	-2.261	-2.344	
3 Negus ..	1764	T. S. & J. D. Negus ..		-1.574	-1.619	-1.553	-1.414	-1.654	-1.594	
4 do ..	1748	do ..		+0.907	+0.881	+0.840	+0.729	+0.489	+0.620	
5 Bliss ..	2817	John Bliss & Co. ..		-0.110	-0.333	-0.410	-0.450	-0.547	-0.380	
6 do ..	2851	do ..		-1.074	-1.119	-1.231	-1.200	-1.047	-1.094	
7 Negus ..	1444	T. S. & J. D. Negus ..		-0.789	-0.869	-0.946	-0.914	-0.869	-1.094	
8 do ..	1519 S. B. C.	do ..		-0.771	-0.889	-0.930	-0.933	-1.173	-1.231	
9 Bond ..	221	Wm. Bond & Son ..		-0.896	-0.797	-0.017	+0.300	+0.274	+0.191	
10 Negus ..	1787	T. S. & J. D. Negus ..		-2.610	-2.940	-2.874	-2.986	-3.154	-3.309	
11 Bliss ..	464	Usher & Cole ..		-0.074	-0.119	-0.089	+0.014	-0.119	-0.201	
12 do ..	2792	John Bliss & Co. ..		+0.140	-0.154	-0.196	-0.093	+0.167	+0.156	
13 Heinrich ..	1007	H. H. Heinrich ..		+0.604	+0.596	+0.661	+0.836	+0.846	+0.763	
14 Negus ..	1259	T. S. & J. D. Negus ..		-0.753	-0.869	-0.910	-0.700	-0.797	-1.023	
15 do ..	1762	do ..		+0.211	+0.167	+0.483	+0.586	+0.774	+0.691	
16 do ..	1636	do ..		+1.247	+1.203	+1.197	+1.157	+0.989	+1.013	
17 do ..	1536 S. B. C.	do ..		+1.193	+0.969	+1.071	+1.173	+1.150	+1.089	
18 do ..	1267	do ..		-1.217	-1.154	-1.160	-1.236	-1.047	-0.951	
19 do ..	1452	do ..		-0.574	-0.654	-0.803	-1.057	-0.869	-0.809	
20 do ..	1772	do ..		-1.574	-1.583	-1.589	-1.700	-1.797	-1.873	

## Record of trial of repaired chronometers—Continued.

Relative number.	Time .....	Temperature, Fahrenheit .....	Relative humidity, per cent .....	Apr. 13	Apr. 20	Apr. 27	May 4	May 11	May 18	May 25
				to	to	to	to	to	to	to
				Apr. 20.	Apr. 27.	May 4.	May 11.	May 18.	May 25.	June 1.
21	Negus 509	Wm. Bond & Son ..	+2.819	+2.810	+2.911	+2.800	+2.989	+3.049	+3.127	
22	do 1448	T. S. & J. D. Negus ..	-0.003	-0.047	-0.053	+0.086	+0.060	-0.166	-0.087	
23	Bliss 2381	John Poole .....	-0.824	-0.833	-0.767	-0.914	-0.690	-0.773	-0.730	
24	Bond 504	Wm. Bond & Son ..	-1.789	-2.083	-2.374	-1.629	-1.547	-2.344	-2.301	
25	Negus 1189	T. S. & J. D. Negus ..	+1.890	+1.774	+1.911	+1.907	+1.631	+1.727	+1.699	
26	do 1268	do .....	-0.360	-0.440	-0.731	-0.843	-0.797	-0.809	-0.659	
27	Bond 272	Wm. Bond & Son ..	+0.676	-0.011	-0.231	-0.700	-0.869	-0.951	-0.337	
28	Bliss 25568	M. F. Dent .....	+0.283	+0.203	+0.090	-0.021	-0.154	-0.451	-0.480	
1	1890	T. S. & J. D. Negus ..	-1.931	-2.154	-2.160	-2.129	-2.226	-2.273	-2.373	
2	1754	do .....	+2.461	+2.310	+2.590	+2.586	+2.310	+2.263	+2.234	
3	1872	do .....	+0.140	+0.131	-0.017	-0.129	-0.190	-0.309	-0.409	
4	1810	do .....	+0.961	+0.881	+0.876	+0.907	+1.024	+1.120	+0.984	
5	1021	H. H. Heinrich .....	-5.253	-5.226	-5.231	-4.807	-4.333	-4.773	-4.909	
6	994	do .....	-3.110	-3.190	-3.517	-3.450	-3.476	-3.487	-3.408	
7	1849	T. S. & J. D. Negus ..	-0.753	-0.833	-0.839	-0.843	-0.976	-1.094	-1.230	
8	1833	do .....	-1.610	-1.797	-1.910	-2.021	-2.011	-2.273	-2.623	
9	1874	do .....	-1.646	-1.726	-1.874	-1.771	-2.011	-2.309	-2.266	
10	1873	do .....	-1.717	-2.154	-2.089	-2.236	-2.404	-2.666	-2.659	

Relative number.	Time .....	Temperature, Fahrenheit .....	Relative humidity, per cent .....	June 1	June 8	Tempera- ture of compens- ation.	Tempera- ture con- stant.	First trial num- ber.	Final trial num- ber.
				to	to				
				June 8.	June 15.				
1	Negus 1776	T. S. & J. D. Negus ..	-0.296	-0.479	95.16	+0.00068	9.617	9.903	
2	Bond 505	Wm. Bond & Son ..	-2.510	-2.443	68.64	+0.00252	8.130	10.853	
3	Negus 1764	T. S. & J. D. Negus ..	-1.474	-1.514	67.32	+0.00261	10.092	10.884	
4	do 1748	do .....	+0.419	+0.236	81.52	+0.00028	9.663	11.445	
5	Bliss 2817	John Bliss & Co .....	-0.689	-0.871	20.73	-0.00009	8.746	11.535	
6	do 2851	do .....	-1.260	-1.220	81.64	+0.00005	9.992	12.095	
7	Negus 1444	T. S. & J. D. Negus ..	-0.939	-0.979	71.41	+0.00278	13.055	14.495	
8	do 1519	S. B. C. .....	-1.279	-1.351	65.09	+0.00247	13.345	14.533	
9	Bond 221	Wm. Bond & Son ..	+0.204	-0.086	82.62	+0.00046	4.034	14.564	
10	Negus 1787	T. S. & J. D. Negus ..	-3.296	-3.479	67.09	+0.00249	12.594	15.300	
11	Bliss 464	Usher & Cole .....	-0.331	-0.336	66.01	+0.00226	14.937	15.353	
12	do 2792	John Bliss & Co .....	+0.204	+0.521	41.93	+0.00063	13.764	15.402	
13	Heinrich 1007	H. H. Heinrich .....	+0.847	+0.950	67.33	+0.00296	16.934	17.199	
14	Negus 1259	T. S. & J. D. Negus ..	-1.010	-0.907	65.77	+0.00345	16.878	17.644	
15	do 1762	do .....	+0.490	+0.450	68.83	+0.00299	22.407	24.270	
16	do 1636	do .....	+0.919	+0.950	68.72	+0.00268	24.442	24.918	
17	do 1536	S. B. C. .....	+1.080	+1.290	63.57	+0.00358	28.731	28.933	
18	do 1267	do .....	-1.010	-0.979	80.56	+0.00193	28.955	30.568	
19	do 1452	do .....	-0.796	-0.836	77.46	+0.00263	29.632	30.754	
20	do 1772	do .....	-1.939	-2.050	73.86	+0.00168	30.842	31.754	
21	do 509	Wm. Bond & Son ..	+3.133	+3.021	65.40	+0.00155	34.742	35.516	
22	do 1448	T. S. & J. D. Negus ..	-0.154	+0.093	64.13	+0.00272	35.550	35.706	
23	Bliss 2381	John Poole .....	-0.760	-1.014	75.01	+0.004412	40.395	41.995	
24	Bond 504	Wm. Bond & Son ..	-2.189	-1.907	80.48	-0.00342	42.251	45.473	
25	Negus 1189	T. S. & J. D. Negus ..	+1.847	+1.486	55.69	+0.00174	50.313	53.625	
26	do 1268	do .....	-0.724	-0.764	70.90	+0.00467	64.894	67.422	
27	Bond 272	Wm. Bond & Son ..	-1.010	-1.764	69.66	+0.00184	44.046	47.472	
28	Bliss 25568	M. F. Dent .....	-0.867	-0.907	70.32	+0.00353	72.391	78.394	
1	1890	T. S. & J. D. Negus ..	-2.403	-2.407	68.51	+0.00296	9.404	11.017	
2	1754	do .....	+2.169	+2.200	67.79	+0.00236	12.388	13.319	
3	1872	do .....	-0.439	-0.550	70.47	+0.00369	18.996	20.472	
4	1810	do .....	+0.883	+0.980	70.02	+0.00369	20.676	21.105	
5	1021	H. H. Heinrich .....	-5.224	-4.943	66.58	+0.00298	21.837	25.917	
6	994	do .....	-3.117	-3.229	76.32	+0.00109	26.333	30.019	
7	1849	T. S. & J. D. Negus ..	-1.296	-1.336	75.68	+0.00303	20.386	30.308	
8	1833	do .....	-2.653	-2.764	68.65	+0.00504	41.253	46.005	
9	1874	do .....	-2.296	-2.086	68.52	+0.00296	42.612	46.552	
10	1873	do .....	-2.680	-2.586	66.30	+0.00329	103.047	109.240	

During the year 24 comparing and 15 stop watches have been subjected to trial, of which 11 comparing and 10 stop watches were purchased.

Thirty maximum and minimum thermometers have also been purchased.

The performance of the three clocks in this department has been satisfactory, and the mean time of noon (seventy-fifth meridian) as determined by observation has been sent out on every day of the year except Sundays. The average error for the year of the noon signals was 0.23 second.

The reports from branch hydrographic offices continue to show that the signal is received with a fair degree of regularity.

Mr. M. E. Porter, computer, has done excellent work as assistant in this office.

Very respectfully,

CHAS. E. FOX,

Lieutenant, U. S. N.,

*Head of Department Chronometers and Time Service.*

#### DEPARTMENT OF MAGNETISM AND METEOROLOGY.

Mr. J. N. James, electrician, has had charge of this department during the year. The regular routine observations have been made. Owing to the proximity of the electric railway on the Tennytown road, the readings of the self-registering instruments have been greatly disturbed, and their value is very questionable.

Unless some means can be devised for protecting these instruments from local disturbances, the work in this department will hardly accomplish the purposes for which they were installed. I shall bring to the attention of my successor the difficulties that have been encountered, with the hope that they may be overcome.

#### LIBRARY.

Assistant Librarian William D. Horigan has direct charge of the library, under the general supervision of the library committee.

	Volumes.	Pamphlets.	Total.
Contents of library July 1, 1896 .....	15,456	3,304	18,760
Accessions .....	580	107	687
Contents July 1, 1897 .....	16,036	3,411	19,447

Of the accessions, 292 were received as exchanges and 395 were purchased.

#### BUILDINGS AND GROUNDS.

Satisfactory progress has been made in the improvements of the grounds and roads.

The two new houses erected for residences of observers are now occupied.

The buildings are generally in good condition.

Leaks through walls on the north side of the Superintendent's residence have developed during recent storms to a degree that will necessitate a careful inspection and such repairs as may prove to be necessary for its preservation.

Very respectfully,

R. L. PHYTHIAN,

*Commodore, U. S. N., Superintendent of Naval Observatory.*

The CHIEF OF THE BUREAU OF EQUIPMENT,

*Navy Department, Washington D. C.*



